IS 10106-3-4 (1988): Packaging code, Part 3: Ascillary materials, Section 4: Desiccants [TED 24: Transport Packages]

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UDC 621·798·2·02 [66·047·82] : 006·76 (First Reprint DECEMBER 1996)

Indian Standard

(Reaffirmed 2003)

PACKAGING CODE

PART 3 ANCILLARY MATERIALS

Section 4 Desiccants

Packaging Code Sectional Committee, MCPD 24 [Ref : Doc : MCPD 24 (692)]

1. Scope — Gives guidance on the use of desiccants in packaging and also describes the factors which should govern the choice of desiccant in the field of packaging.

2. Terminology

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 *Barrier* — Any material providing physical shield against ingress of water-vapour which causes deterioration to the packaged article. This may be used in the form of a liner or as a coating.

2.2 *Desiccant* — A material used to take up water-vapour from the air-space within a container or from air passed through it.

2.3 *Dunnage* — Any materials within the barrier other than the packeged item, for example, packing or blocking materials, instrument cases, etc.

2.4 *Hygroscopic* — Capable of absorbing water-vapour from the surrounding atmosphere. Absorption will continue until an equilibrium is reached and this is dependent upon the conditions of temperature and relative humidity of the atmosphere. For many substances, this is a reversible process so that if the moisture content is in excess of the equilibrium value water-vapour will be given off until equilibrium conditions are established.

3. General

3.1 Dampness not only encourages corrosion but can also cause growth of moulds and bacteria even when water is not present. Various steps can be taken to reduce the adverse effect of moisture on a packed article such as application of temporary protective treatment against corrosion to metallic surfaces or the proofing of textiles. Such direct protection is not practicable for all articles, specially for certain electrical components of scientific and optical instruments. An ideal method of providing protection in such instances is by using a completely sealed package. There may still be damp air inside the container, and the moisture may be given off by cushioning material used to hold the articles in position. Furthermore, few materials used in making sealed packages are completely resistant to penetration of water-vapour and a certain amount of moisture may reach the articles through the walls of the package. Desiccants are, therefore, essentially used to take-up moisture that may be in package from any of these sources.

3.2 *Humidity* — Air naturally contains moisture in the form of vapour. The quantity of moisture present in a unit volume is known as absolute humidity. At any particular temperature, the air can hold only a limited amount of water-vapour; the higher its temperature, the more water-vapour the air can hold. Air containing as much water-vapour as it can hold is said to be saturated. If saturated air is cooled, it will give up by condensation just enough of its moisture as liquid water to leave it saturated at the lower temperature.

The maximum quantity of moisture which can be held in vapour form by the atmospheric air is determined by the temperature. The hygrometric tables and charts provide this data for a whole range of temperature.

3.2.1 *Relative humidity* — Normally air is not saturated with water-vapour unless it is in close contact with liquid water. The actual amount of water-vapour present in air (that is, the absolute humidity) expressed as a percentage of amount the air contains when saturated at the same temperature is called the relative humidity or RH. For example, suppose a cubic metre of air contains 5 g of water-vapour and that air if saturated at the same temperature would contain 20 g of water-vapour per cubic metre, then the air has a relative humidity of:

$$\frac{5}{20} \times 100 = 25 \text{ percent}$$

Saturated air, of course, has a relative humidity of 100 percent.

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3.2.2 The relative humidity of atmosphere is the dominating factor in determining whether the corrosion of metals, mould growth, rotting, etc, will take place. It is known, for example, that at ordinary temperatures, corrosion of iron is extremely slow at relative humidities below 60 percent but becomes rapid at higher humidities. Mould growth does not, in general, take place, or is extremely slow unless the relative humidity is above 70 percent. Generally, for engineering products a 50 percent relative humidity level has been found to be the critical level and provides a tolerance against a sudden fall in temperature but for other products, other critical levels may apply.

4. Desiccated Packages

4.1 *General* — The deterioration of many articles can be minimized by applying suitable treatment to the article itself either during or after manufacture. Sometimes such treatment is not practicable or desirable and it is still necessary to protect the contents. One method of doing this is to ensure that the relative humidity of the atmosphere in contact with the item never exceeds a safe limit which is generally taken in practice to be 50 percent.

A package that contains a sufficient quantity of suitable desiccant to ensure that the RH within it will not exceed this figure when stored in any part of the world for a specified period is called desiccated package. An essential requirement of such a pack is that it should contain sufficient quantity of a suitable desiccant to reduce the relative humidity within the pack to 50 percent or less and maintain this for the desired period. To assist in maintaining this reduced level of humidity, the entry of water-vapour is retarded. There are various ways of achieving this. Hermetically sealed metal containers may be used, or the container may incorporate or be made from a water-vapour barrier, that is a material with a high resistance to the passage of water-vapour. It is rarely possible to exclude air from such packages or to avoid the use of interior packaging materials that contain some moisture.

4.2 *Sources of Moisture* — For any package, four sources of moisture generally encountered are described below.

4.2.1 The air inside the barrier contains some water-vapour.

4.2.2 The air outside the barrier is the most important source of moisture even in a sealed container except a perfectly sealed metal or glass container which may be completely water-vapour proof. The way in which the water passes through the sealed barrier is not important here but 'waterproof' material is not necessarily even moderately water-vapour-proof. Air-tightness is an even less reliable criterion than waterproofness. The implication of this is that if the relative humidity outside the package is higher that inside, there is a tendency for moisture to pass into the package. Often in many countries, the relative humidity is 80 to 100 percent and since that of the atmosphere inside the package is to be kept below 50 percent, the transmission of water-vapour may be considerable.

4.2.3 Hygroscopic materials inside the barrier are a considerable source of moisture. For example, wood and paperboard are both hygroscopic and will give up moisture if temperature rises. The packaged item itself may create a problem if it is made in part from hygroscopic materials.

4.2.4 *Trapped water* — There is always a possibility of water being trapped within the article, for example, in pumps after testing, or water being entrained in any oil remaining in an oil bath. Certain non-hygroscopic materials used for packaging contain water as a result of their manufacturing process. Expert guidance should be sought to deal with this problem.

5. Factors Governing Choice of Desiccant

5.1 *General Management of the Desiccant* — A desiccant maintains a safe relative humidity within the package by absorbing most of the moisture from the air and any moisture arising from the goods or internal hygroscopic materials. It will further absorb any moisture which enters the package through the barrier but only for a calculated period.

The desiccant should be in a dustproof container that will prevent its spreading throughout the pack and at the same time allow the desiccant to absorb the moisture from the atmosphere within the pack. There are many dehydrating agents that can be used but certain properties such as moisture-absorbing capacity, chemical inertness, etc, make some materials more suitable than others for use as desiccants in packaging.

5.2 *Important Factors* — In the selection of desiccant for a particular pack, the important factors to be considered are given below:

a) *Moisture absorbing capacity of desiccant in relation to bulk and mass* — In order to maintain a safe relative humidity inside a desiccated package, it is essential to have present sufficient desiccant to cater for all possible sources of moisture. In order to minimize the space required in the package for desiccant, it is desirable to use materials of high moisture absorbing capacity.

b) *Stability and physical form of the desiccant* — The physical form of the desiccant should by such as to expose maximum surface of desiccant and allow diffusion of package atmosphere through its mass. The desiccant container should be designed to minimize hindrance to such diffusion.

These conditions are best satisfied if the desiccant is available in the form of coarse granules, or tablets.

The desiccant should retain its form throughout the performance of its function, that is, it should remain solid and dry to the touch and suffer little or no disintegration.

The material should be such that the absorption of moisture is not accompanied by chemical changes that will cause it to corrode or otherwise damage its container or the article packed. It should not produce a liquid or gas or a significant rise in temperature.

c) *Influence of normal temperature range on the moisture absorbing capacity of desiccant* — Desiccants remove moisture from the atmosphere in one of the two ways, for example:

i) physically, and

ii) chemically.

Moisture taken up by chemical combination is firmly held and is not liberated by temperature increase normally encountered in the environment.

Moisture taken up physically is held less firmly and an increase in temperature can cause the desiccant to give up moisture to the atmosphere. It is important, therefore, that those desiccants which take up moisture physically should not give it up again in sufficient quantities to affect materially the relative humidity if the temperature rises.

d) *Means of containing the desiccant* — It is essential that the moisture in the package should be able to reach the desiccant and that the desiccant or dust from it should not be allowed to spread throughout the package. For this reason, importance is attached to the containers in which the unit quantities of desiccant are held. The considerations discussed in **7** should, therefore, be taken into account in selecting a unit container for the desiccant. The unit containers should be firmly anchored and properly distributed inside the package.

e) The desiccants may be indicative or non-indicative type. The indicative type on absorption of moisture (on losing its activation) changes in colour.

5.3 *Summary* — The various factors described under **5.2** restrict the number of desiccants that are suitable for packaging. The desiccants most commonly used for packaging are:

a) Silica gel,

b) Activated alumina, and

c) Activated clays.

5.3.1 For extremely critical packaging conditions where very low relative humidities (below 10 percent) are to be maintained, molecular sieve desiccants should be used. Any of these materials may be suitable in general but for specific application, a final choice should be made only in relation to nature of the article to be packed. Expert guidance should be sought before finally selecting a desiccant for a particular commodity. The following Indian Standards should also be consulted in this regard:

IS : 3401-1979 Silica gel (*second revision*), and

IS : 9700-1981 Activated alumina.

The formulae given under **6.2.1.1** for determining the quantity of basic desiccant used in a package cannot be applied to molecular sieve desiccants. Advice should be sought from suppliers of molecular sieve desiccants as to the appropriate conditions and mode of use in each case.

6. Quantity of Desiccant

6.1 The actual quantity of desiccant necessary in any package depends on the following factors.

6.1.1 *Type of water-vapour barrier* — The layer or layers of the package that are intended to exclude water-vapour constitute the water-vapour barrier. Some barriers will allow the passage of water-vapour only at an extremely slow rate but even at this rate, the relative humidity may become dangerously high in the absence of a desiccant after a few days under humid conditions.

The important factor is the water-vapour transmission rate (WVTR) of the barrier material. This rate is determined experimentally under standard conditions and is expressed in grams per square metre per 24 hours. Method for determinating water transmission rate of flexible materials is given in IS : 1060 (Part 2)-1960 'Methods of sampling and test for paper and allied products: Part 2'. Typical figures for WVTR for some of the materials are given in Table 1.

TABLE 1 WVTR OF VARIOUS MATERIALS AT 38°C AND 90 PERCENT RH

(*Clause* 6.1.1)

Material	Thickness μm	Typical WVTR $g/m^2 \cdot 24\ h$
Low density polyethylene	65	10
	150	3·4
	250	2
High density polyethylene	25	25
Cross linked orientated polyethylene	75	3·5
	150	2·6
Polypropylene	50	2·3
Polyvinyl chloride (PVC)	100	31
	225	9
Polyester	60	11
	120	4
Polyvinylidene chloride (PVDC)	25	5
Fluorocarbon co-polymer	250	0·15
Aluminium foil laminate	75	0·05

From the transmission rate, it is possible to calculate the quantity of desiccant necessary to keep the relative humidity inside a package below the critical level for any specified period under the climatic conditions it is expected to encounter. The better the barrier, the less the desiccant required; if no moisture can enter, no desiccant is required to deal with it though it would still be necessary to absorb moisture derived from interior packaging material and enclosed air. Any seals employed should at least be as adequate as the barrier material.

Note — In service packaging, water-vapour barriers are classified as follows:

a) *Water-vapour resistant* — Offering a high resistance to the passage of water-vapour; transmission rate (WVTR) shall not exceed 8 g/m^2. 24 h when measured at a temperature of 38°C and a relative humidity of 90 percent.

b) *Water-vapour proof* — Offering a high resistance to the passage of water-vapour; the water-vapour transmission rate (WVTR) shall not exceed 1 g/m^2. 24 h when measured at a temperature of 38°C and a relative humidity of 90 percent.

6.1.2 *Area of the barrier* — The surface area should be kept as small as possible.

6.1.3. *Weight of hygroscopic material inside the barrier* — Sufficient desiccant should be used to absorb moisture given off by hygroscopic materials such as wood and paperboard present inside the water-vapour barrier and thus reduce the relative humidity to a safe value. All hygroscopic materials tend to reach equilibrium with the surrounding atmosphere at a relatively slow rate.

If a desiccant is used, equilibrium is reached between the moisture in the package atmosphere and that in the hygroscopic material and the desiccant. It is necessary, therefore, to include enough desiccant to absorb the moisture that may be given off by the hygroscopic material at elevated temperatures and to ensure that the relative humidity can in no circumstances be above 50 percent.

6.1.4 *Required period of storage* — It is the total time elapsing between sealing the package by the packer and its first opening.

6.1.5 *Volume of air inside the barrier* — The volume of air inside the package contains water-vapour and allowance for this is made in the calculations given under **6.2**.

Note — For extremely sensitive articles, the outer packing is preferably done in a partially dehumidified room particularly during the wet season.

6.2 *Calculation of Quantity of Desiccant Required*

6.2.1 *Basic desiccant* — A series of formulae have been determined which permit the user to calculate the quantity of desiccant required to provide protection under varying modes of usage. In using these formulae, protection is defined as the maintenance of relative humidity within the package at 50 percent (or less) during the calculated period of storage.

There are several different types of desiccants (*see* **5.3**) which may be used for such applications, all of which have a differing moisture absorption capability. As it is not practical to redefine the formulae for each type of desiccant, the calculations are based on the concept of basic desiccant, the derivation of which is as follows:

Basic desiccant is defined as a product capable of absorbing 27 percent of moisture on its dry weight at 50 percent relative humidity and 25°C.

Note — Silica gel manufactured to IS : 3401-1979 'Silica gel (*second revision*)' conforms with this requirement and, therefore, can be equated directly to the basic desiccant quantity calculated in the formulae. If alternative desiccant systems are used, it is essential to ascertain the absorption capacity under defined conditions. For example desiccant, activated clay may absorb 20 percent of moisture on its dry weight and where activated clay is not supplied in basic desiccant units then more material in the ratio 27 : 20 or 1·35 times the quantity will be required to achieve the same absorbancy. Hence using the formulae to calculate basic desiccant requirements for activated clay requires the answer to be multiplied by 1·35 to give the basic desiccant quantity in grams of activated clay.

Service requirements are for the supply of desiccant in basic desiccant units.

6.2.1.1 *Formulae*

a) Where goods are shipped through, or stored in tropical conditions subject to normal commercial distribution and warehousing practice

$$W = 40\,ARM + DF \qquad (1)$$

b) Where goods are shipped and stored in temperate climates subject to normal commercial practice

$$W = 11\,ARM + DF \qquad (2)$$

c) Where goods are packed to military specifications for extended storage periods of not less than two years duration under predicted temperature and humidity conditions

Unheated covered storage worldwide $W = 24\,ARM + DF$ (3)

Heated covered storage worldwide $W = 6\,ARM + DF$ (4)

d) Where goods are packed in completely water-vapour impervious barriers, such as, hermetically sealed glass, or metal containers

Non-thermally insulated $W = 170\,V + DF$ (5)

Thermally insulated $W = 70\,V + DF$ (6)

e) Where goods are packed in a container manufactured from a water-vapour impervious material, such as, glass or metal fitted with a removable closure and when the sealing gasket is known to be capable of water-vapour transmission, the formulae in (d) become

Non-thermally insulated $W = 170\,V + 90\,R_s LM + DF$ (7)

Thermally insulated $W = 70\,V + 90\,R_s LM + DF$ (8)

where

W = mass of basic desiccant in g;

A = area of water-vapour barrier in m^2;

M = maximum storage time in months;

R = water-vapour transmission rate of the barrier measured at 90 percent RH and 38°C in $g/m^2.24$ h;

V = volume of free air inside the barrier in m^3;

L = length of seal (gasket) in m;

R_s = water-vapour transmission rate of the seal in g/m length 24 h;

D = mass of dunnage inside the barrier in g; and

F = a factor dependent upon the type of dunnage used as follows:
1/5 for timber of moisture content greater than 14 percent;
1/8 for felt, carton board and similar packaging materials;
1/10 for plywood and timber with less 14 percent moisture content; and
0 for expanded polyethylene or expanded polystyrene.

Examples of calculations are given in Appendix A.

7. General Packaging Considerations

7.1 *Conditions in Use* — In order that the desiccant shall be fully effective in use, it is imperative that:

a) the desiccant is in a fully activated condition;

b) it can be reached by the air within the water-vapour barrier but is prevented from spreading over the items in the package;

c) it is in perfect condition as regards its moisture-absorbing capacity when it is placed within the barrier; and

d) as much as possible of the dunnage material is placed outside the barrier.

7.2 *Methods of Meeting Desired Conditions* — The following paragraphs give guidance on methods of meeting these requirements.

7.2.1 The desiccant should be in unit containers such as bags or sachets which should be fastened securely within the water-vapour barrier so that they will not wander or chafe.

7.2.2 Bags of desiccant are available in vaious sizes providing quantities of any particular desiccant equivalent in moisture-absorbing capacity to weight units of basic desiccant. Commercial desiccants can be obtained in unit containers equivalent to 25 g, 50 g, 100 g, 250 g, 500 g, 1 kg, 2·5 kg, and 5 kg of basic dessicant (B. D.).

7.2.3 In order to achieve the requirement mentioned in **7.1**(b) above, the units should be packed, transported and stored in sealed metal containers. The latter should be kept closed until the packer is ready to transfer and seal the required amount of desiccant into a space within the water-vapour barrier, the metal container being closed immediately after transfer. It is not usually a good policy to obtain a bulk container of such a size that it has to be continually opened and shut in order to withdraw small numbers of units. It is preferable to have a larger number of small bulk containers. Indicator papers enclosed in the container should be checked as a guide whether the desiccant is still in good condition.

7.2.4 The quantity of desiccant required for a particular package can be pre-determined by calculation (*see* **6.2**). The distribution of the desiccant requires careful thought so that, wherever possible, the size of the barrier is not increased to accommodate the desiccant. Where dimensions are critical, the use of an alternative or thicker barrier material should be considered. It is often possible to utilize the empty spaces within the barrier by breaking down the total quantity of desiccant required into convenient units. For example, if a package would have to be increased in size to accommodate say, four bags, the substitution of eight or more smaller bags in the empty spaces might serve the purpose without increasing the size. Provided the physical limits of the item to be packaged allow, the unit containers should be spread as evenly as possible throughout the package rather than be concentrated in one position.

7.2.5 Desiccant should not be removed from its unit container in order to add small quantities to a package. Unit containers only should be used.

It is sometimes advisable to make separate compartments for the necessary unit containers, both for convenience in packing and unpacking, and ease of securing, but if this method is adopted then adequate provision must be made to ensure a free circulation of air within the barrier. If hygroscopic material is used for these compartments, due allowance must be made (*see* **6.1.3**). In the packaging of certain items, such as precision instruments, it is essential to prevent desiccant dust from escaping from its container. Special containers are available for this purpose.

To safeguard against accidental sifting of desiccant from the unit containers, it is advisable that the packaged item be suitably protected so that the dust cannot filter into small orifices, oil holes, etc.

7.2.6 Desiccant which for accidental or other reasons have been exposed to the atmosphere should never be introduced or re-introduced into the barrier.

Where goods are sent for export shipment, there is a danger of the water-vapour-proof barrier being damaged by customs examination and steps should be taken to avoid this, otherwise it may be necessary to re-desiccate and reseal the package. When calculating the amount of desiccant required, it is desirable to allow for unforeseen delays in transit. The expiry date should always be stamped on the package.

APPENDIX A

(*Clause* 6.2.1.1)

EXAMPLE OF CALCULATING THE REQUIRED QUANTITY OF DESICCANTS

A-1. Example 1

A-1.1 A precision grinding machine, supported by felt covered timber is enclosed in a 150-μm thick polyethylene barrier. The whole enclosed in an export packing case made of tongued and grooved timber, lined with waterproof paper and with felt on the roof. All the material outside the polyethylene barrier can be ignored in calculating the quantity of desiccant required.

Dimensions of barrier	122 × 168 × 91 cm
Mass of timber supports	6 120 g
Mass of felt	680 g
Maximum storage	12 months in tropical climates

From the above information:

$A = 9{\cdot}4\ \text{m}^2$

Dunnage to be allowed for timber supports $\quad DF = \dfrac{6\,120}{5}\ \text{g}$

Dunnage to be allowed for felt $\quad DF = \dfrac{680}{8}\ \text{g}$

Storage period $\quad M = 12$ months

WVTR of barrier (*see* **6.1.1**) $\quad R = 3{\cdot}4\ \text{g/m}^2.24\ \text{h}$

Therefore, from formula (1) [*see* **6.2.1.1(a)**]:

$$W = 40\,ARM + DF$$
$$= 40 \times 9{\cdot}4 \times 3{\cdot}4 \times 12 + \frac{6\,120}{5} + \frac{680}{8}$$
$$= 16\,649{\cdot}8\ \text{g}$$

It would be practical in this case to use 17 kg of basic desiccant.

A-2. Example 2

A-2.1 A 5 kVA generating set, squared off with plywood enclosed in a polyethylene barrier 500-μm thick (2 thicknesses of 250 μm material) then floated in a cushioning material inside a timber case. The case and cushioning material can be ignored as they are outside the barrier.

Dimensions of barrier	120 × 150 × 60 cm
Mass of plywood	900 g
Maximum storage	6 months in tropical climates

From the above information:

$A = 6{\cdot}9\ \text{m}^2$

Dunnage to be allowed for plywood $\quad DF = \dfrac{900}{10}\ \text{g}$

Storage period $\quad M = 6$ months

WVTR of barrier (*see* **6.1.1**) $\quad R = 1\ \text{g/m}^2.24\ \text{h}$

Therefore, from formula (1) [*see* **6.2.1.1(a)**]:

$$W = 40\,ARM + DF$$
$$= 40 \times 6{\cdot}9 \times 1 \times 6 + \frac{900}{10}$$
$$= 1\,746\ \text{g}$$

It would be practical in this case to use 1 800 g or even 2 kg of basic desiccant.

A-3. Example 3

A-3.1 A machine, the sharp projections on which are padded with expanded polyethylene sheets secured with adhesive tape and enclosed in a barrier of aluminium foil laminate.

Dimensions of barrier	Mostly cylindrical 275 cm long and 122 cm diameter, tapered at one end to 76 cm diameter and adding 61 cm to the height.
Maximum storage	6 months in temperate climate

From the above information:

	$A = 14{\cdot}1\ m^2$
Storage period	$M = 6$ months
WVTR of barrier	$R = 0{\cdot}05\ g/m^2.\ 24\ h$

No dunnage allowance is required for expanded polyethylene.

Therefore, from formula **(2)**
[*see* **6.2.1.1(b)**]:

$$\begin{aligned} W &= 11\ ARM + DF \\ &= 11 \times 14{\cdot}1 \times 0{\cdot}05 \times 6 + 0 \\ &= 46{\cdot}5\ g \end{aligned}$$

It would be practical in this case to use 50 g of basic desiccant. Depending on free space inside the barrier, this could be one 50 g bag or several smaller bags to make up 50 g.

A-4. Example 4

A-4.1 Electronic controlgear cushioned in expanded polyethylene and enclosed in a metal container, the lid of which is sealed by a neoprene gasket having a WVTR of $2{\cdot}6 \times 10^{-2}$g/24 h per metre length.

Dimensions of container	46 cm diameter × 36 cm
Length of neoprene seal	1·5 m
Maximum storage	12 months in tropical climates

From the above information:

	$V = 0{\cdot}598\ m^3$
WVTR of neoprene seal	$R_s = 2{\cdot}6 \times 10^{-2}$ g/24 h per metre length
Length of neoprene seal	$L = 1{\cdot}5$ m
Storage period	$M = 12$ months

No dunnage allowance is required for expanded polyethylene.

$$DF = 0$$

Therefore, from formula (7)
[*see* **6.2.1.1(e)**]:

$$\begin{aligned} W &= 170\ V + 90\ R_s\ LM + DF \\ &= (170 \times 0{\cdot}059\ 8) + (90 \times 2{\cdot}6 \times 10^{-2} \times 1{\cdot}5 \times 12) + 0 \\ &= 52{\cdot}29\ g \end{aligned}$$

Bearing in mind that some of the enclosed air will be displaced by the cargo and cushioning material, it would be practical in this case to use 50 g of basic desiccant.

EXPLANATORY NOTE

This section (Part 3/Sec 4) of packaging code gives guidance on the use of desiccants in packaging.

In the preparation of this standard, considerable assistance has been derived from BS 1133 : Section 19 : 1987 'Packaging code: Use of desiccants in packaging', issued by the British Standards Institution (BSI).

Printed at New India Printing Press, Khurja, India